States of Diffusion for n+1 Devices

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ABSTRACT

States of Diffusion is a participative audio installation artwork that explores patterns of sound transformation that move through space as they evolve spectrally. Six one-minute segments exploring themes of intonation and timing of events across possibly many different audio sources are coordinated via a web server. The spatial diffusion flows through mobile devices held by visitors to the gallery. Visitors also exert a subtle influence over sound through the movement of their device and their movement through the gallery.

Categories and Subject Descriptors

H.5.5 [**Information Systems**]: Information Interfaces and Presentation (HCI) – *sound and music computing.*

General Terms

Design; Human Factors

Keywords

Sonic Art; Interactive Audio; Collaboration; Mobility; Web Audio API.

1. OVERVIEW

States of Diffusion is composed for "n+1 devices", where the "n" (1 to 40) are mobile devices brought in to the space and held by gallery visitors, and the "1" is a multi (2, 4, or 8)-channel sound system installed in a gallery space. As the piece evolves, the source of sound is passed between the gallery speakers and hand-held devices. Sound moves across the space through varying patterns of diffusion from the speakers on the mobile devices.

The piece is organized as six one-minute "movements," each based on a different spectrally evolving sound pattern, each using a different strategy for sound diffusion appropriate for the sonic elements being developed. The sound and the diffusion patters are responsive to the movement of gallery visitors through the sensors on the mobile devices. The audience members also determine the spatial diffusion patterns by walking around the space with their devices from which sound is emitted. In this way, audience members physically co-create the sonic space for and with each other.

2. STRUCTURE AND INTERACTION

The platform supporting *States of Diffusion* is a client/server style architecture. Two different websites are served – one for the Gallery sound system, and one for the Visitors. The Gallery and Visitor clients join the piece by pointing their mobile device browsers to the *States of Diffusion* website, and then communicate with each other by exchanging messages via the server using a "chat room" type of architecture.
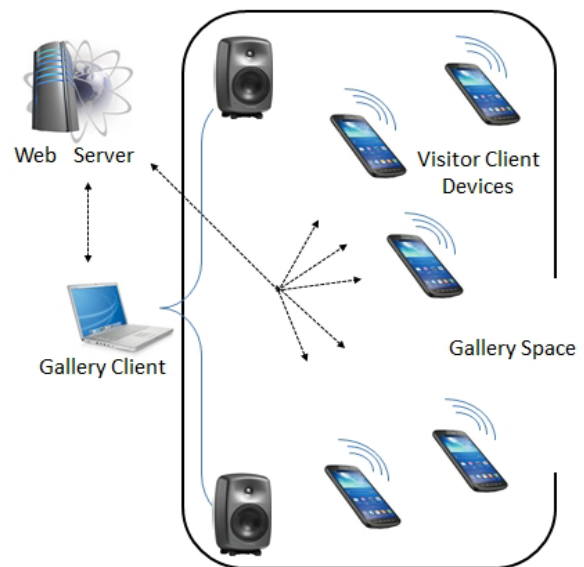

Figure 1. Clients point browsers to the web server to access the *States of Diffusion* website. The Gallery Client determines the progression through 6 movements comprising the work, and sends messages to the Visitor Client mobile devices to coordinate the sound creation and spatial diffusion between the participants.

The Gallery Client is heard through full-range high-fidelity speakers installed in the gallery. The Gallery Client is also responsible for the coordination between all sounding devices, and determines the transition between the six movements of the piece, notifying all other clients as they occur. The Visitor clients all run the same sound-generating program, but each produces different sound at different times (producing the movement of sound through the space) based on an ID each client is assigned when visitors join, messages from the Gallery Client, and the timing within each of the six segments. Variability in the sounds produced on different clients is also a result of input from device

sensors and depends on the direction and angle the devices are pointing as visitors move around the space.

3. ARTISTIC OBJECTIVES

States of Diffusion is about people coming together in one space to collectively create sonic environments with each other. Each of the six movements is related to the others, but distinct in sonic focus. For example, one is based on harmonics of a low (60 Hz) fundamental with a rich overtone structure generated by the Gallery Client's speakers. Visitor devices emit sine tones that are slightly mistuned as the devices move to create "beating" which, because the devices are distributed in the space, seem to move around the space as they constructively and destructively interfere with each other. Two other movements explore rich musical chords (one with singing human voices, the other with breathy synthetic tones) where the movement through space is achieved through the coordination of timing across participant devices. Another movement "granularizes"[6] an environmental sound which shifts in and out of recognizability as the length and density of the grains created by different devices change due to central timing coordination in conjunction with the movement of the devices. Transition between the six segments of the piece overlap slightly, and are related by musical key and/or spatial rhythm. All segments are designed to encourage careful listening and slow exploratory activity as people walk around the gallery establishing different spatial relationships amongst themselves.

3.1 Related Artistic Work

There is long tradition in music of moving sound in space across multitudes of speakers. One of the most well-known systems is the Acousmonium constructed by composer François Bayle at the Groupe de Recherches Musicales (GRM) in Paris[4]. It was comprised of some 80 speakers spread over a stage along with several though the audience. Sound was frequently "diffused" live by a composer or engineer, even if the sound was coming from fixed media such as tape or CD.

Moving speakers have also been used for musical purposes. *Speaker Swinging* by Gordon Monahan used oscillators broadcasting tones over 3 loudspeakers that were swung in circles on speakers at the end of a tether. More recently, the *Pocket Gamelan* series of pieces by Greg Schiemer[5] used mobile phones swung in a similar way. These pieces use space and sound source motion as an integral part of the musical work.

Mobile phones provided by audience members were used in the 2001 *Dialtones (A Telesymphony)* by Golan Levin. This piece is performed by live performers dialing phones that have been prepared with ringtones according to audience seating assignments. In this way, both the sound and the spatial dimensions of the piece were "choreographed" [3].

States of Diffusion thus draws on several historical musical threads, while taking advantage of emerging web technologies that are sensitive in real time to the number of participants and their motion through the space in order to synthesize and diffuse the sound. Visitors are free to explore the interactive elements by moving around the gallery space and moving their devices thereby creating a hybrid between an installation piece and a participative performance.

4. THE VISTOR EXPERIENCE

The gallery space is dimly lit and contains speakers in the corners. A poster identifies the piece, and contains a QR code and a website address that visitors use to direct their mobile device browsers to the State of Diffusion website as the enter.

The website for display on the Visitor Clients has a minimalistic graphic design, with a compass-like icon displaying the compass direction and angle (pitch) of their device. The interactive graphics provide visual feedback designed to encourage and reinforce the movements the audience participants make which influence the sound played on their device.

Devices held by different visitors make sounds at different times – sometimes overlapping, sometimes not. When a given device makes sound, its display also brightens with color – each of the six segments of the piece are associated with a different color. This visual component plays an aesthetic role (imagine fireflies in a field at dusk). As sound moves across the space, so does the pattern of illumination. The light also functions as feedback to make it clear to each participant when their own device is making sound, and to heighten the awareness of their own role in the overall structure of the work.

The piece works for anywhere from one to forty simultaneous visitors. The server knows how many visitor devices are participating at any given time, and assigns "roles" to clients accordingly so that the experience is rich enough when there is only a single or several visitors, yet not too dense when there are many. As visitors walk around, they change the spatial configuration of the sound sources in the gallery. Visitors may enter and leave the gallery at their leisure.

5. TECHNICAL INFORMATION

States of Diffusion is built entirely with HTML5 technologies for both networking and sound synthesis. The server is written using node.js [2], along with the Express web applications framework, and the WebSockets library for network communication.

The client code is written in JavaScript and uses the newly-emerging W3C standard Web Audio API [1] for real-time sound synthesis and the jsaSound sound modeling library written by the author [7]. The jsaSound library "wraps" the low-level Web Audio API with high-level sound-model building capabilities for sound developers, and provides a simple API for interactive for web developers[8].

The recent developments in real-time browser-based sound synthesis technology (along with other HTML5, sensor and processing capabilities of mobile devices) make this kind of co-located inter-browser coordinated sound piece possible merely by having participants navigate to a website. The server is located on the Internet, so that no special apparatus and no local network is necessary (although it may also be run on a local area network if necessary). The installation infrastructure has been tested with up to 40 simultaneously engaged clients, and runs on modern major browsers (Chrome, Safari, Opera) on Mac, PC or mobile devices running Android, iOS, and Windows operating systems.

This is the premier installation of *States of Diffusion*, although the infrastructure and sound synthesis software has been developed during the course of several previous projects.

6. ACKNOWLEDGMENTS

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